# Internal delay calibration at NPLI

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CAL-ID: 1013-2018

## 1 Introduction

NPLI and NICT performed their first G2 calibration campaign with the NICT traveling receiver at NPLI. The period of the calibration at NPLI was from March 12 to May 10, 2018. Table 1 shows the receivers and antennas used for the calibration.

Table 1: List of receivers and antennas.

| *System* | *Receiver* | *Antenna* | *Remark* |
|---|---|---|---|
| NC01 | Septentrio PolaRx2 TR | ASHTECH 701933-02 Rev A | Backup |
| NC4S | Septentrio PolaRx4 TR Pro | AeroAntenna AT1675-120SW | Master |
| NC4C | Septentrio PolaRx4 TR Pro | NovAtel GPS-703-GGG | Traveling |
| LIAA | Dicom GTR-51 | NovAtel GPS-703-GGG | |
| LIAB | Dicom GTR-51 | NovAtel GPS-703-GGG | |
| LIAF | Septentrio PolaRx4 TR Pro | Septentrio SEPPOLANT_X_MF | |
| LITI | Septentrio PolaRx3e TR | Septentrio SEPCHOKE_MC | LI2P |
| LITF | PikTime TTS-4 | Javad JAV_GRANT-G3T | LIT4 |

We performed a common clock measurement based on "BIPM guidelines for GNSS calibration" [1] and calculated the common clock differences (CCDs) from RINEX files since all the receivers were geodetic-type receivers. "concerto v4" (c4) was used as the analysis software [2], and "RTKLIB" software [3] was used to determinted the anntena positions of the traveling receiver.

The internal delays of the NICT reference and traveling receivers were calibrated by BIPM [**?**] as shown in Table 2.

The internal delays of the NPLI receivers with respect to the NICT reference receivers were calculated from the values in Tables 2 and 7, and Table 3 shows the results of these calculations. The results of LIAA and LIAB (Dicom GTR-51) show differences from the a priori values. We estimated the uncertainty of this calibration using equation 1.

$$U_{CAL} = \sqrt{U_{ref}^2 + U_{cal}^2} \tag{1}$$

Table 2: Internal delays of the reference receivers (all values in ns).

| *Sys.* | *Date* | *REF* | *CAB* | *C1* | *P1* | *P2* | $U_{CAL}$ |
|---|---|---|---|---|---|---|---|
| NC01 | 2017.12 | 408.2 | 213.4 | 221.4 | 218.3 | 222.4 | 2.3 |
| NC4S | 2017.12 | 314.9 | | 278.2 | 276.8 | 276.3 | 2.3 |
| NC4C | 2017.12 | 594.4 | 157.5 | 56.4 | 54.9 | 53.3 | 2.3 |

Table 3: Internal delays of the NPLI receivers (all values in ns).

| *Sys.* | *Ref.* | *REF* | *CAB* | *C1* | *P1* | *P2* | $U_{CAL}$ |
|---|---|---|---|---|---|---|---|
| LIAA | Ave. | 96.7 | 132.9 | **-31.6** | **-32.6** | **-31.4** | |
| | | | | (-8.6) | (-6.7) | (-4.5) | 2.9 |
| | NC01 | | | -8.54 | -6.64 | -4.54 | |
| | NC4S | | | -8.62 | -6.67 | -4.53 | |
| LIAB | Ave. | 96.5 | 132.2 | **-31.6** | **-32.4** | **-32.1** | |
| | | | | (-10.1) | (-6.3) | (-2.6) | 2.9 |
| | NC01 | | | -10.02 | -6.31 | -2.64 | |
| | NC4S | | | -10.10 | -6.33 | -2.63 | |
| LIAF | Ave. | 247.1 | 168.9 | **50.8** | **49.6** | **50.5** | 2.9 |
| | NC01 | | | 50.85 | 49.59 | 50.52 | |
| | NC4S | | | 50.76 | 49.57 | 50.52 | |
| LITF | Ave. | 90.1 | 142.2 | **-24.6** | **-26.7** | **-26.6** | 2.9 |
| | NC01 | | | -24.52 | -26.72 | -26.61 | |
| | NC4S | | | -24.60 | -26.74 | -26.60 | |
| LITI | Ave. | 284.1 | 150.0 | **52.9** | **53.1** | **58.3** | 2.9 |
| | NC01 | | | 52.93 | 53.08 | 58.31 | |
| | NC4S | | | 52.84 | 53.06 | 58.32 | |

Where $U_{ref}$ is the uncertainty of the reference receiver, given in Table 2, and $U_{cal}$ is the total uncertainty of this calibration, given in Table 8.

## 2 Results of raw data processing

Table 4 shows the average CCDs between the traveling receiver and each reference or target receiver, and Figures 1 to 9 show raw plots and the time deviation of each CCD. We used single difference observations of each code (C1, P1, and P2) between receivers, and solved the receiver clock offsets every 1 hour. The raw plots show the estimated CCDs as receiver clock offsets.

## 3 Calibration results

Table 5 shows the ΔSYSDLY values for the traveling receiver with respect to the reference receivers. These values were calculated using equation (2).

$$\Delta\text{SYSDLY}_{A-B} = \text{CCD}_{A-B} + \text{REFDLY}_A - \text{REFDLY}_B \tag{2}$$

Table 4: Summary of the raw calibration results (all values in ns).

| *Pair* | *Date* | *CCD (C1)* | $U_a$ | *CCD (P1)* | $U_a$ | *CCD (P2)* | $U_a$ |
|---|---|---|---|---|---|---|---|
| NC4C - NC01 | 58089 - 58126 | -407.174 | 0.2 | -405.603 | 0.2 | -411.612 | 0.2 |
| NC4C - NC4S | 58089 - 58126 | -344.059 | 0.2 | -344.105 | 0.2 | -344.980 | 0.1 |
| NC4C - LIAA | 58189 - 58248 | -2.371 | 0.4 | -5.727 | 0.4 | -9.308 | 0.2 |
| NC4C - LIAB | 58189 - 58248 | -0.894 | 0.3 | -6.066 | 0.3 | -11.210 | 0.2 |
| NC4C - LIAF | 58189 - 58248 | 16.441 | 0.3 | 16.241 | 0.4 | 13.837 | 0.2 |
| NC4C - LITF | 58189 - 58248 | -38.491 | 0.3 | -37.751 | 0.3 | -39.340 | 0.2 |
| NC4C - LITI | 58189 - 58248 | 70.263 | 0.3 | 68.647 | 0.3 | 61.943 | 0.3 |
| NC4C - NC01 | 58331 - 58342 | -188.386 | 0.2 | -186.678 | 0.2 | -191.818 | 0.2 |
| NC4C - NC4S | 58331 - 58342 | -145.372 | 0.2 | -145.322 | 0.2 | -146.335 | 0.1 |

"No" in Table 5 indicates the measurement period at NICT, where No. 1 denotes preliminary

Table 5: Computed ΔSYSDLY values for the traveling systems with respect to reference receivers. (all values in ns)

| *Pair* | *No* | $REF_T$ | $REF_R$ | *C1 (ns)* | | *P1 (ns)* | | *P2 (ns)* | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | *CCD* | ΔSYS | *CCD* | ΔSYS | *CCD* | ΔSYS |
| NC4C - NC01 | 1 | 594.4 | 408.2 | -407.17 | -220.93 | -405.60 | -219.36 | -411.61 | -225.37 |
| NC4C - NC01 | 2 | 382.9 | 415.2 | -188.39 | -220.69 | -186.68 | -218.98 | -191.82 | -224.12 |
| | | *Misclosure* | | | -0.25 | | -0.39 | | -1.25 |
| | | *Mean* | | | -220.81 | | -219.17 | | -224.75 |
| NC4C - NC4S | 1 | 594.4 | 314.9 | -344.06 | -64.52 | -344.10 | -64.57 | -344.98 | -65.44 |
| NC4C - NC4S | 2 | 382.9 | 301.6 | -145.37 | -64.07 | -145.32 | -64.02 | -146.33 | -65.03 |
| | | *Misclosure* | | | -0.45 | | -0.54 | | -0.41 |
| | | *Mean* | | | -64.30 | | -64.29 | | -65.24 |

measurements and No. 2 denotes closure measurements.

Table 6 shows the ΔSYSDLY values for the NPLI receivers with respect to the traveling receiver. The reference delay of the traveling receiver ($\mathrm{REFDLY}_T$) was calculated from equation (3) with reference to page 14 and page 21.

$$\mathrm{REFDLY}_T = \mathrm{CLB\ P}_k + [\mathrm{c201c} - \mathrm{c301c}] + 39.0\mathrm{ns} - 15.3\mathrm{ns} \tag{3}$$

*Note* (∗1): GTR-51 with the $\mathrm{REFDLY}_V$ value introduced a priori.

Table 7 shows the ΔINTDLY values for the NPLI receivers with respect to the reference receivers. ΔSYSDLY in Table 7 was obtained from equation (4) and ΔINTDLY was obtained from equation (5).

$$\Delta\mathrm{SYSDLY}_{V-R} = \Delta\mathrm{SYSDLY}_{T-R} - \Delta\mathrm{SYSDLY}_{T-V} \tag{4}$$

$$\Delta\mathrm{INTDLY}_{V-R} = \Delta\mathrm{SYSDLY}_{V-R} - \mathrm{CABDLY}_V + \mathrm{CABDLY}_R \tag{5}$$

*Note* (∗2): GTR-51 with $\mathrm{CAVDLY}_V$ value introduced a priori.

Table 6: Computed ΔSYSDLY values for the visited systems with respect to the traveling system (all values in ns).

| *Pair* | $REF_T$ | $REF_V$ | *C1 (ns)* | | *P1 (ns)* | | *P2 (ns)* | |
|---|---|---|---|---|---|---|---|---|
| | | | *CCD* | ΔSYS | *CCD* | ΔSYS | *CCD* | ΔSYS |
| NC4C - LIAA | 224.9 | ∗1 | -2.37 | 222.53 | -5.73 | 219.17 | -9.31 | 215.59 |
| NC4C - LIAB | 224.9 | ∗1 | -0.89 | 224.01 | -6.07 | 218.83 | -11.21 | 213.69 |
| NC4C - LIAF | 224.9 | 247.1 | 16.44 | -5.76 | 16.24 | -5.96 | 13.84 | -8.36 |
| NC4C - LITF | 224.9 | 90.1 | -38.49 | 96.31 | -37.75 | 97.05 | -39.34 | 95.46 |
| NC4C - LITI | 224.9 | 284.1 | 70.26 | 11.06 | 68.65 | 9.45 | 61.94 | 2.74 |

Table 7: Computed ΔINTDLY values for the visited systems with respect to the reference receivers (all values in ns).

| *Pair* | $CAB_V$ | $CAB_R$ | *C1 (ns)* | | *P1 (ns)* | | *P2 (ns)* | |
|---|---|---|---|---|---|---|---|---|
| | | | ΔSYS | ΔINT | ΔSYS | ΔINT | ΔSYS | ΔINT |
| LIAA - NC01 | ∗2 | 213.4 | -443.34 | -229.94 | -438.34 | -224.94 | -440.34 | -226.94 |
| LIAB - NC01 | ∗2 | 213.4 | -444.82 | -231.42 | -438.01 | -224.61 | -438.44 | -225.04 |
| LIAF - NC01 | 168.9 | 213.4 | -215.05 | -170.55 | -213.21 | -168.71 | -216.38 | -171.88 |
| LITF - NC01 | 142.2 | 213.4 | -317.12 | -245.92 | -316.22 | -245.02 | -320.21 | -249.01 |
| LITI - NC01 | 150.0 | 213.4 | -231.87 | -168.47 | -228.62 | -165.22 | -227.49 | -164.09 |
| LIAA - NC4S | ∗2 | 0.0 | -286.82 | -286.82 | -283.47 | -283.47 | -280.83 | -280.83 |
| LIAB - NC4S | ∗2 | 0.0 | -288.30 | -288.30 | -283.13 | -283.13 | -278.93 | -278.93 |
| LIAF - NC4S | 168.9 | 0.0 | -58.54 | -227.44 | -58.33 | -227.23 | -56.88 | -225.78 |
| LITF - NC4S | 142.2 | 0.0 | -160.60 | -302.80 | -161.34 | -303.54 | -160.70 | -302.90 |
| LITI - NC4S | 150.0 | 0.0 | -75.36 | -225.36 | -73.74 | -223.74 | -67.98 | -217.98 |

# 4 Uncertainty estimation

Table 8 shows the uncertainty of the calibration. The method of estimating the uncertainty is the same as that in [4].

# Revision history

**Revision 0.1** Draft version.

**Revision 0.2** Correction of a few typos.

**Revision 1.0** First release of final report.

**Revision 1.1** Fix the wrong reference for the uncertainty computation, and add 4 chars BIPM code of LITI and LITF receivers.

# References

[1] BIPM guidelines for GNSS calibration V3.2 15/02/2016.

Table 8: Uncertainty contributions. Values P3 are computed as $P1 + 1.545x(P1 - P2)$

| *Uncertainty* | *Value C1/P1 (ns)* | *Value P2 (ns)* | *Value P1 - P2 (ns)* | *Value P3 (ns)* | *Description* |
|---|---|---|---|---|---|
| $u_a(T-R)$ | 0.20 | 0.20 | 0.28 | | CCD (traveling - reference) |
| $u_a(T-V)$ | 0.40 | 0.30 | 0.50 | | CCD (traveling - visited) |
| $u_a$ | 0.45 | 0.36 | 0.57 | 0.99 | |
| Misclosure | | | | | |
| $u_{b,1}$ | 0.47 | 0.93 | 0.74 | | Observed misclosure |
| Systematic components related to CCD | | | | | |
| $u_{b,11}$ | 0.05 | 0.05 | 0.05 | | Position error at reference |
| $u_{b,12}$ | 0.05 | 0.05 | 0.05 | | Position error at visited |
| $u_{b,13}$ | 0.30 | 0.30 | 0.42 | | Multipath at reference |
| $u_{b,14}$ | 0.30 | 0.30 | 0.42 | | Multipath at visited |
| Link from the traveling system to the local UTC(k) | | | | | |
| $u_{b,21}$ | 0.50 | 0.50 | 0.00 | | $\text{REFDLY}_T$ (at reference) |
| $u_{b,22}$ | 0.50 | 0.50 | 0.00 | | $\text{REFDLY}_T$ (at visited) |
| $u_{b,TOT}$ | 0.83 | 0.83 | 0.60 | 1.25 | |
| Link from the reference system to its local UTC(k) | | | | | |
| $u_{b,31}$ | 0.50 | 0.50 | 0.00 | | $\text{REFDLY}_R$ |
| Link from the visited system to its local UTC(k) | | | | | |
| $u_{b,32}$ | 0.50 | 0.50 | 0.00 | | $\text{REFDLY}_V$ |
| $u_{b,SYS}$ | 1.18 | 1.15 | 0.83 | 1.74 | |
| $u_{CAL}$ | | | | 1.74 | |


[2] T.Gotoh, et al, Proc. 21th EFTF and IFCS, pp.1188—1193, 2007.

[3] http://www.rtklib.com/, online

[4] "4.4 Uncertainty estimation", Annex 4 Template for the calibration report, BIPM Guidelines for GNSS equipment calibration.

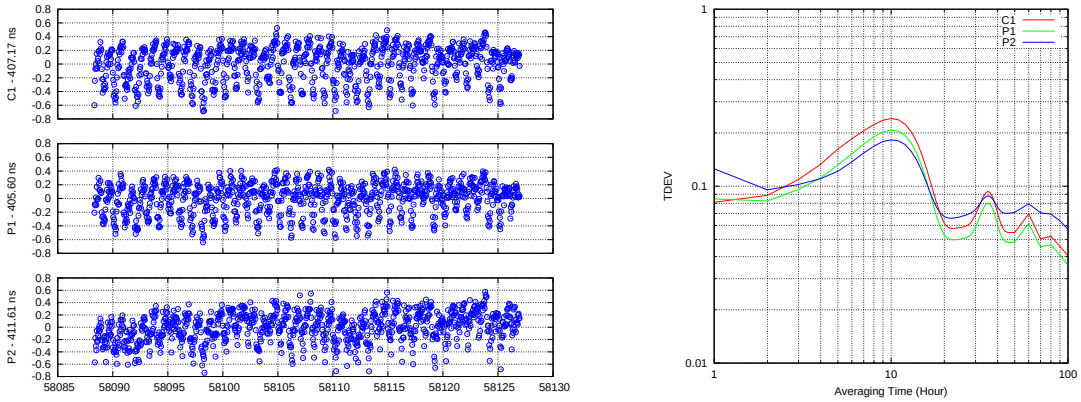



Figure 1: Common clock differences between NC01 and NC4C (preliminary).

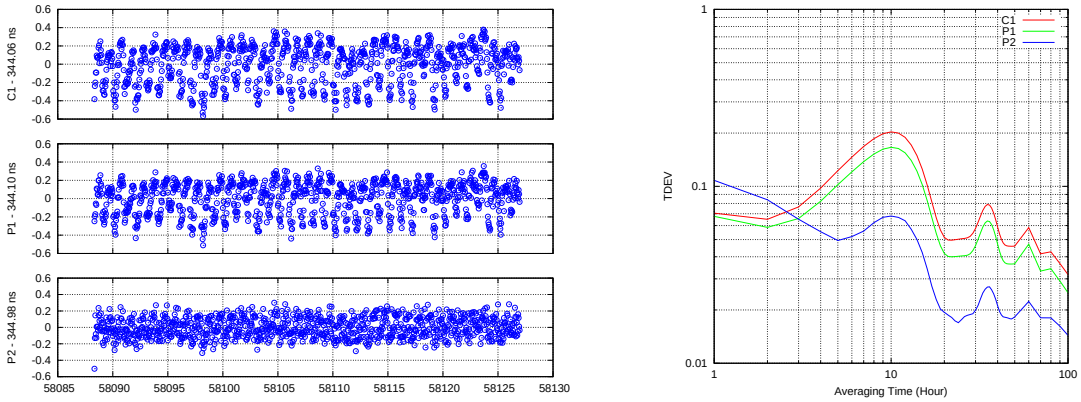



Figure 2: Common clock differences between NC4S and NC4C (preliminary).

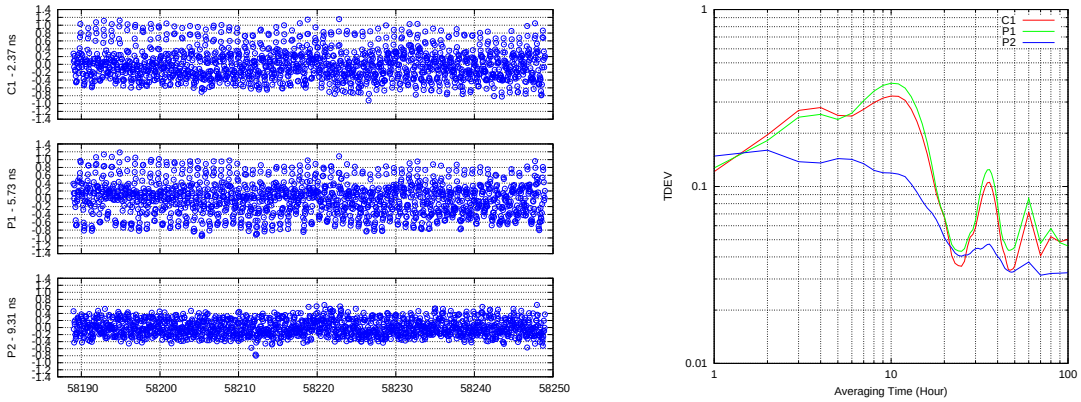



Figure 3: Common clock differences between LIAA and NC4C.

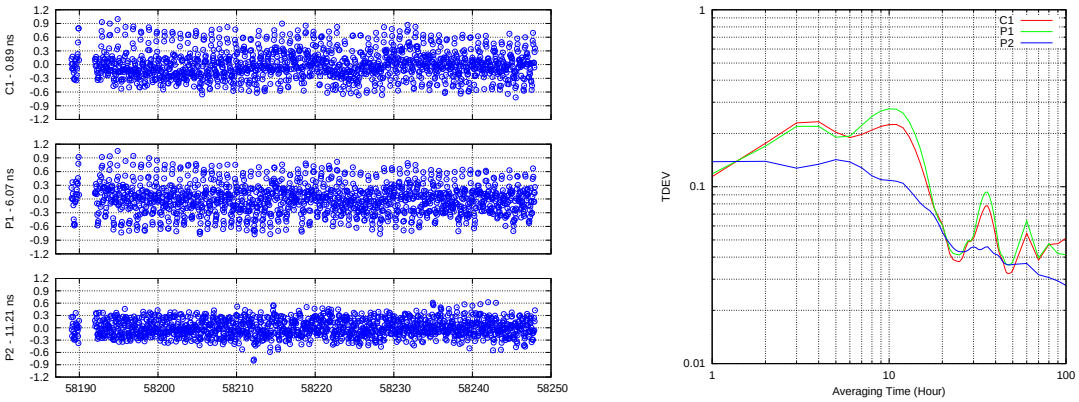



Figure 4: Common clock differences between LIAB and NC4C.

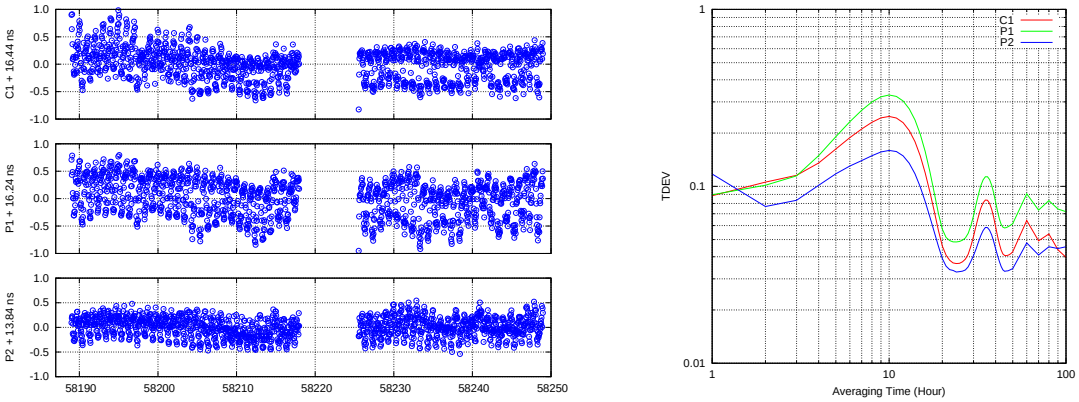



Figure 5: Common clock differences between LIAF and NC4C.

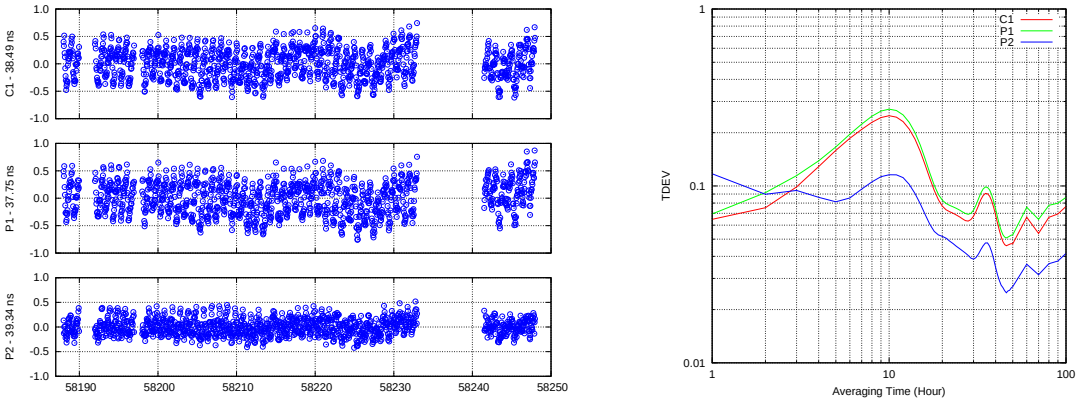



Figure 6: Common clock differences between LITF and NC4C.

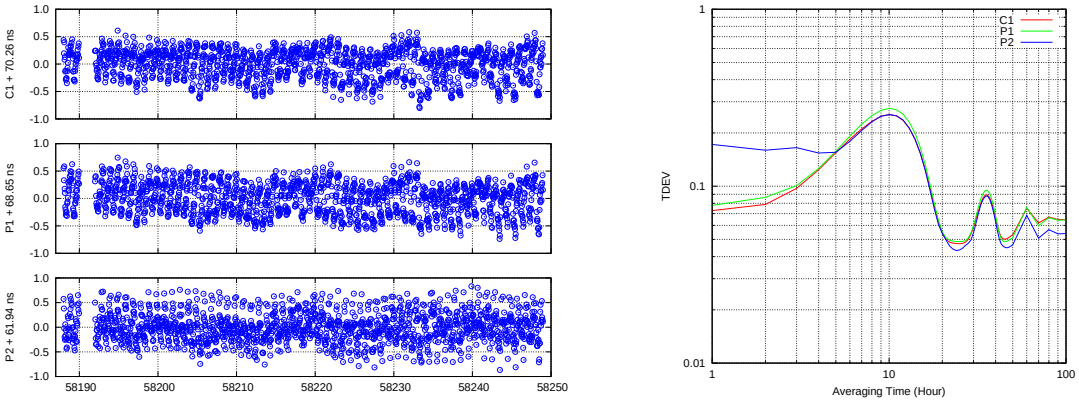



Figure 7: Common clock differences between LITI and NC4C.

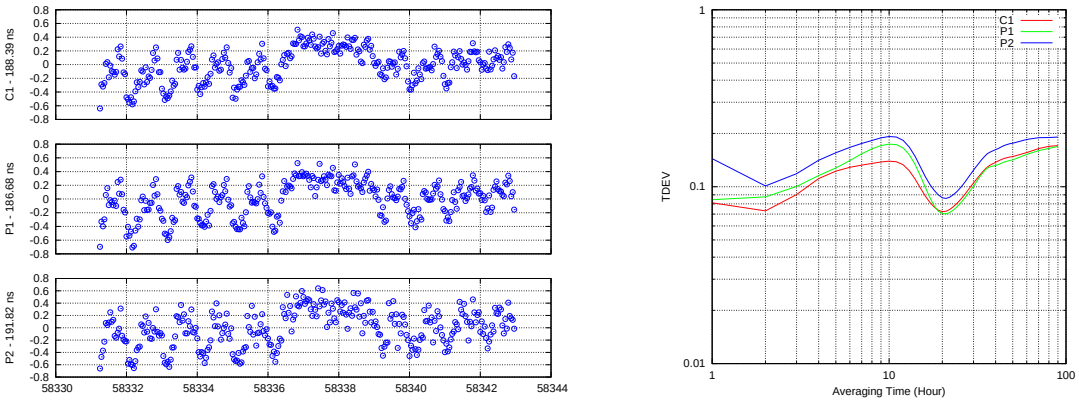



Figure 8: Common clock differences between NC01 and NC4C (closure).

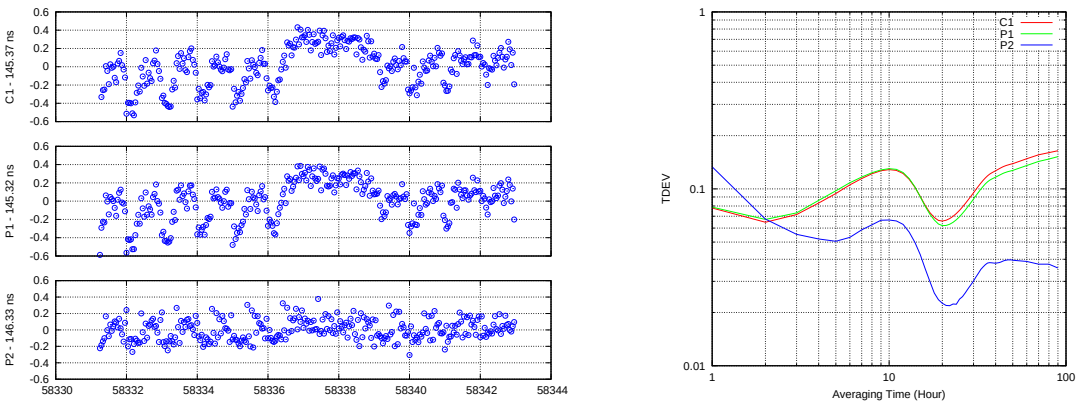



Figure 9: Common clock differences between NC4S and NC4C (closure).

# Annex A - Information Sheet

(to be repeated for each calibrated system)

| | |
|---|---|
| Laboratory: | NICT |
| Date and hour of the beginning of measurements: | **Dec. 2, 2017 0h UTC** |
| Date and hour of the end of measurements: | **Jan. 8, 2018 24h UTC** |

## Information on the system

| | **Local:** | **Travelling:** |
|---|---|---|
| 4-character BIPM code | NC01 | NC4C |
| • Receiver maker and type:<br>Receiver serial number: | Septentrio PolaRx2 TR<br>S/N: 1354 Rev A | Septentrio PolaRx4 TR Pro<br>S/N: 3102270 |
| 1 PPS trigger level /V: | | |
| • Antenna cable maker and type:<br>Phase stabilised cable (Y/N): | FUJIKURA 8D-SFA-LITE<br>Phase stabilised: No | FUJIKURA 5D-SFA-LITE<br>Phase stabilised: No |
| Length outside the building /m: | | |
| • Antenna maker and type:<br>Antenna serial number: | ASHTECH 701933-02 Rev A<br>CRN21999080101 | NovAtel GPS-703-GGG<br>S/N: 01018146 |
| Temperature (if stabilised) /°C | | |

## Measured delays /ns

(if needed fill box "Additional Information" below)

| | **Local:** | **Travelling:** |
|---|---|---|
| • Delay from local UTC to receiver 1 PPS-in: | 165.1 ns | 458.0 ns |
| Delay from 1 PPS-in to internal Reference (if different):<br>(see section 2 for details) | 234.4 ns<br>165.1 + 234.4 + 8.7 = 408.2 ns | 136.4 ns<br>458.0 + 136.4 = 594.4 ns |
| • Antenna cable delay: | 213.4 ns | 157.5 ns |
| Splitter delay (if any): | | |
| Additional cable delay (if any): | | |

## Data used for the generation of CGGTTS files

| | |
|---|---|
| • INT DLY (GPS) /ns: | 221.4 ns (C1), 218.3 ns (P1), 222.4 ns (P2) |
| • INT DLY (GLONASS) /ns: | |
| • CAB DLY /ns: | 213.4 ns |
| • REF DLY /ns: | 408.2 ns |
| • Coordinates reference frame: | |
| Latitude or X /m: | -3942091.48 m |
| Longitude or Y /m: | 3368258.70 m |
| Height or Z /m: | 3701996.21 m |

## General information

| | |
|---|---|
| • Rise time of the local UTC pulse: | |
| • Is the laboratory air conditioned: | Yes |
| Set temperature value and uncertainty: | 24 degC |
| Set humidity value and uncertainty: | 40 % |

(1) For a trip with closure, not needed if the traveling equipment is used in the same set-up throughout.

(to be repeated for each calibrated system)

| | |
|---|---|
| Laboratory: | NICT |
| Date and hour of the beginning of measurements: | **Dec. 2, 2017 0h UTC** |
| Date and hour of the end of measurements: | **Jan. 8, 2018 24h UTC** |

## Information on the system

| | **Local:** | **Travelling:** |
|---|---|---|
| 4-character BIPM code | NC4S | NC4C |
| • Receiver maker and type:<br>Receiver serial number: | Septentrio PolaRx4 TR Pro<br>S/N: 3102252 | Septentrio PolaRx4 TR Pro<br>S/N: 3102270 |
| 1 PPS trigger level /V: | | |
| • Antenna cable maker and type:<br>Phase stabilised cable (Y/N): | FUJIKURA 8D-SFA-LITE<br>Phase stabilised: No | FUJIKURA 5D-SFA-LITE<br>Phase stabilised: No |
| Length outside the building /m: | | |
| • Antenna maker and type:<br>Antenna serial number: | AeroAntenna AT1675-120SW<br>S/N: 5411 | NovAtel GPS-703-GGG<br>S/N: 01018146 |
| Temperature (if stabilised) /°C | | |

## Measured delays /ns

(if needed fill box "Additional Information" below)

| | **Local:** | **Travelling:** |
|---|---|---|
| • Delay from local UTC to receiver 1 PPS-in: | 166.4 ns | 458.0 ns |
| Delay from 1 PPS-in to internal Reference (if different):<br>(see section 2 for details) | 148.2 ns<br>166.4 + 148.2 = 314.6 ns | 136.4 ns<br>458.0 + 136.4 = 594.4 ns |
| • Antenna cable delay: | | 157.5 ns |
| Splitter delay (if any): | | |
| Additional cable delay (if any): | | |

## Data used for the generation of CGGTTS files

| | |
|---|---|
| • INT DLY (GPS) /ns: | 278.2 ns (C1), 276.8 ns (P1), 276.3 ns (P2) |
| • INT DLY (GLONASS) /ns: | |
| • CAB DLY /ns: | |
| • REF DLY /ns: | 314.6 ns |
| • Coordinates reference frame: | |
| Latitude or X /m: | -3942091.42 m |
| Longitude or Y /m: | 3368261.97 m |
| Height or Z /m: | 3701993.35 m |

## General information

| | |
|---|---|
| • Rise time of the local UTC pulse: | |
| • Is the laboratory air conditioned: | Yes |
| Set temperature value and uncertainty: | 24 degC |
| Set humidity value and uncertainty: | 40 % |

(1) For a trip with closure, not needed if the traveling equipment is used in the same set-up throughout.

(to be repeated for each calibrated system)

| | |
|---|---|
| Laboratory: | NICT |
| Date and hour of the beginning of measurements: | **Aug. 1, 2018 0h UTC** |
| Date and hour of the end of measurements: | **Aug. 12, 2018 24h UTC** |

## Information on the system

| | **Local:** | **Travelling:** |
|---|---|---|
| 4-character BIPM code | NC01 | NC4C |
| • Receiver maker and type:<br>Receiver serial number: | Septentrio PolaRx2 TR<br>S/N: 1354 Rev A | Septentrio PolaRx4 TR Pro<br>S/N: 3102270 |
| 1 PPS trigger level /V: | | |
| • Antenna cable maker and type:<br>Phase stabilised cable (Y/N): | FUJIKURA 8D-SFA-LITE<br>Phase stabilised: No | FUJIKURA 5D-SFA-LITE<br>Phase stabilised: No |
| Length outside the building /m: | | |
| • Antenna maker and type:<br>Antenna serial number: | ASHTECH 701933-02 Rev A<br>CRN21999080101 | NovAtel GPS-703-GGG<br>S/N: 01018146 |
| Temperature (if stabilised) /°C | | |

## Measured delays /ns

(if needed fill box "Additional Information" below)

| | **Local:** | **Travelling:** |
|---|---|---|
| • Delay from local UTC to receiver 1 PPS-in: | | 238.6 ns |
| Delay from 1 PPS-in to internal Reference (if different):<br>(see section 2 for details) | 406.5 ns<br>406.5 + 8.7 = 415.2 ns | 144.3 ns<br>238.6 + 144.3 = 382.9 ns |
| • Antenna cable delay: | 213.4 ns | 157.5 ns |
| Splitter delay (if any): | | |
| Additional cable delay (if any): | | |

## Data used for the generation of CGGTTS files

| | |
|---|---|
| • INT DLY (GPS) /ns: | 221.4 ns (C1), 218.3 ns (P1), 222.4 ns (P2) |
| • INT DLY (GLONASS) /ns: | |
| • CAB DLY /ns: | 213.4 ns |
| • REF DLY /ns: | 417.2 ns |
| • Coordinates reference frame: | |
| Latitude or X /m: | -3942091.48 |
| Longitude or Y /m: | 3368258.70 |
| Height or Z /m: | 3701996.21 |

## General information

| | |
|---|---|
| • Rise time of the local UTC pulse: | |
| • Is the laboratory air conditioned: | Yes |
| Set temperature value and uncertainty: | 24 degC |
| Set humidity value and uncertainty: | 40 % |

(1) For a trip with closure, not needed if the traveling equipment is used in the same set-up throughout.

(to be repeated for each calibrated system)

| | |
|---|---|
| Laboratory: | NICT |
| Date and hour of the beginning of measurements: | **Aug. 1, 2018 0h UTC** |
| Date and hour of the end of measurements: | **Aug. 12, 2018 24h UTC** |

## Information on the system

| | **Local:** | **Travelling:** |
|---|---|---|
| 4-character BIPM code | NC4S | NC4C |
| • Receiver maker and type:<br>Receiver serial number: | Septentrio PolaRx4 TR Pro<br>S/N: 3102252 | Septentrio PolaRx4 TR Pro<br>S/N: 3102270 |
| 1 PPS trigger level /V: | | |
| • Antenna cable maker and type:<br>Phase stabilised cable (Y/N): | FUJIKURA 8D-SFA-LITE<br>Phase stabilised: No | FUJIKURA 5D-SFA-LITE<br>Phase stabilised: No |
| Length outside the building /m: | | |
| • Antenna maker and type:<br>Antenna serial number: | AeroAntenna AT1675-120SW<br>S/N: 5411 | NovAtel GPS-703-GGG<br>S/N: 01018146 |
| Temperature (if stabilised) /°C | | |

## Measured delays /ns

(if needed fill box "Additional Information" below)

| | **Local:** | **Travelling:** |
|---|---|---|
| • Delay from local UTC to receiver 1 PPS-in: | | 238.6 ns |
| Delay from 1 PPS-in to internal Reference (if different):<br>(see section 2 for details) | 301.6 ns | 144.3 ns<br>238.6 + 144.3 = 382.9 ns |
| • Antenna cable delay: | | 157.5 ns |
| Splitter delay (if any): | | |
| Additional cable delay (if any): | | |

## Data used for the generation of CGGTTS files

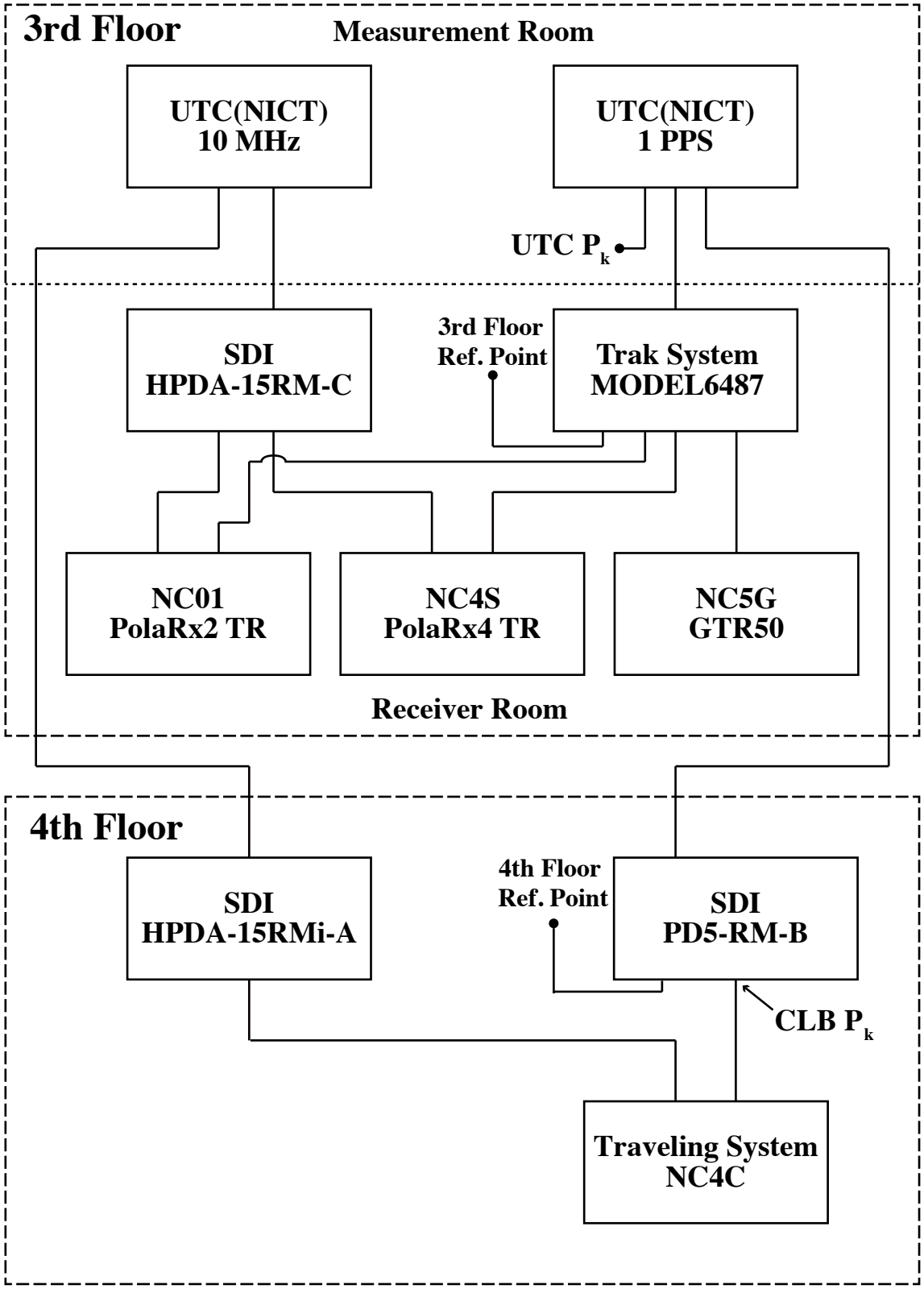
| | |
|---|---|
| • INT DLY (GPS) /ns: | 278.2 ns (C1), 276.8 ns (P1), 276.3 ns (P2) |
| • INT DLY (GLONASS) /ns: | |
| • CAB DLY /ns: | |
| • REF DLY /ns: | 303.8 ns |
| • Coordinates reference frame: | |
| Latitude or X /m: | -3942091.42 |
| Longitude or Y /m: | 3368261.97 |
| Height or Z /m: | 3701993.35 |

## General information

| | |
|---|---|
| • Rise time of the local UTC pulse: | |
| • Is the laboratory air conditioned: | Yes |
| Set temperature value and uncertainty: | 24 degC |
| Set humidity value and uncertainty: | 40 % |

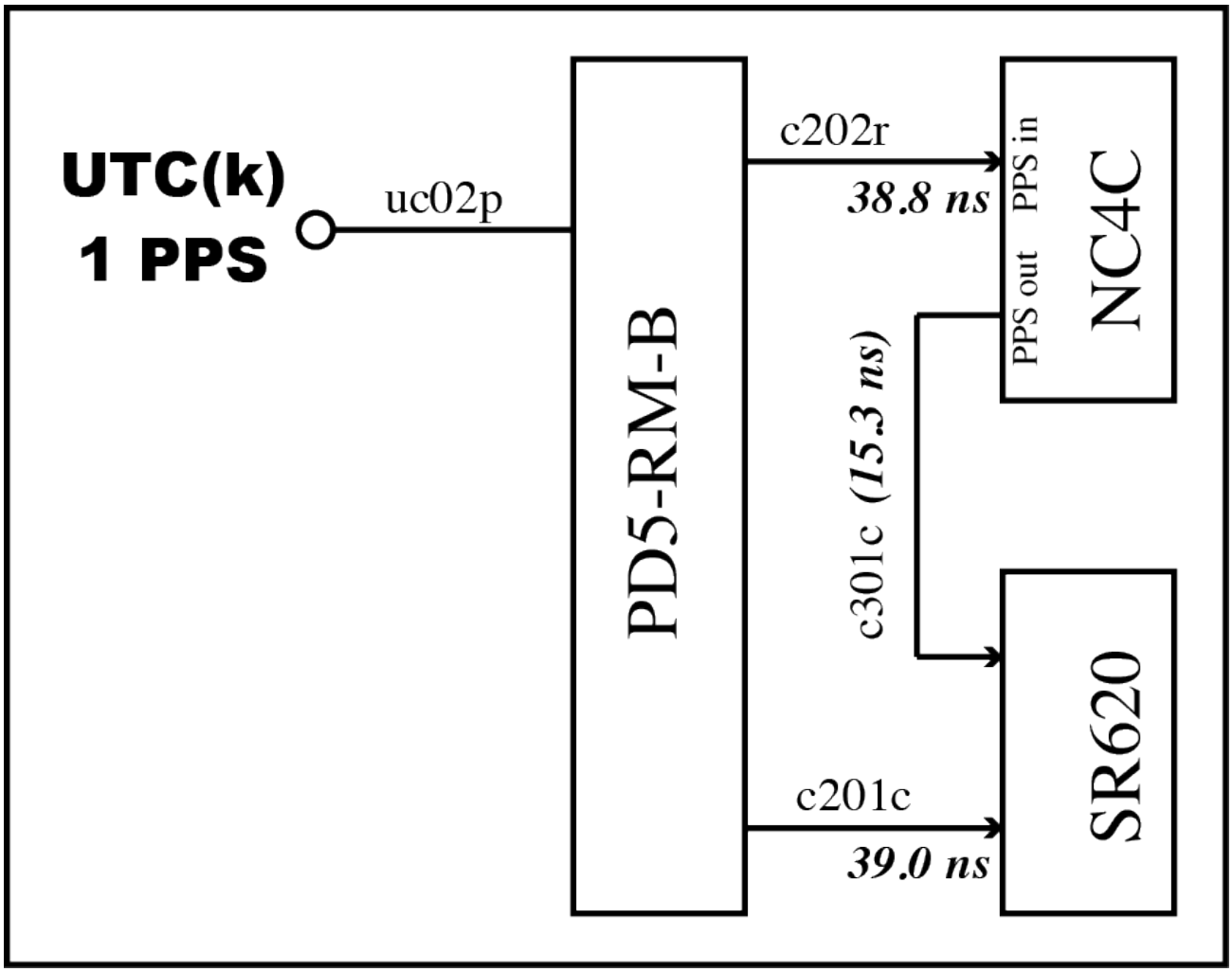
(1) For a trip with closure, not needed if the traveling equipment is used in the same set-up throughout.

## Diagram of the experiment set-up:



**Log of Events / Additional Information :**

Internal Delays of the NICT Traveling System



# Annex A - Information Sheet

(to be repeated for each calibrated system)

| | |
|---|---|
| Laboratory: | NPLI |
| Date and hour of the beginning of measurements: | **12th March, 2018, 00 hour UTC** |
| Date and hour of the end of measurements: | **10th May, 2018, 24 hour UTC** |

## Information on the system

| | **Local:** | **Travelling:** |
|---|---|---|
| 4-character BIPM code | LI2P | NC4C |
| • Receiver maker and type:<br>Receiver serial number: | Septentrio, POLARX3ETR<br>2002984 | |
| 1 PPS trigger level /V: | | |
| • Antenna cable maker and type:<br>Phase stabilised cable (Y/N): | | |
| Length outside the building /m: | ~20m | |
| • Antenna maker and type:<br>Antenna serial number: | Septentrio, SEPCHOKE_MC<br>5025 | |
| Temperature (if stabilised) /°C | | |

## Measured delays /ns

(if needed fill box "Additional Information" below)

| | **Local:** | **Travelling:** |
|---|---|---|
| • Delay from local UTC to receiver 1 PPS-in: | 96.1 | |
| Delay from 1 PPS-in to internal Reference (if different):<br>(see section 2 for details) | 188.0 | |
| • Antenna cable delay: | 150.0 | (1) |
| Splitter delay (if any): | | (1) |
| Additional cable delay (if any): | | (1) |

## Data used for the generation of CGGTTS files

| | |
|---|---|
| • INT DLY (GPS) /ns: | 59.8(P1), 63.0(P2) |
| • INT DLY (GLONASS) /ns: | |
| • CAB DLY /ns: | 150.0 |
| • REF DLY /ns: | 284.1 |
| • Coordinates reference frame: | ITRF |
| Latitude or X /m: | +1243910.55 |
| Longitude or Y /m: | +5462560.57 |
| Height or Z /m: | +3038746.90 |

## General information

| | |
|---|---|
| • Rise time of the local UTC pulse: | <5ns |
| • Is the laboratory air conditioned: | Yes |
| Set temperature value and uncertainty: | $22^0C \pm 1^0C$ |
| Set humidity value and uncertainty: | 50%±5% |

(1) For a trip with closure, not needed if the traveling equipment is used in the same set-up throughout.

# Annex A - Information Sheet

(to be repeated for each calibrated system)

| | |
|---|---|
| Laboratory: | NPLI |
| Date and hour of the beginning of measurements: | **12th March, 2018, 00 hour UTC** |
| Date and hour of the end of measurements: | **10th May, 2018, 24 hour UTC** |

## Information on the system

| | **Local:** | **Travelling:** |
|---|---|---|
| 4-character BIPM code | LIT4 | NC4C |
| • Receiver maker and type:<br>Receiver serial number: | Pik Time, TTS4<br>0131 | |
| 1 PPS trigger level /V: | | |
| • Antenna cable maker and type:<br>Phase stabilised cable (Y/N): | | |
| Length outside the building /m: | ~20m | |
| • Antenna maker and type:<br>Antenna serial number: | Javad, JAV_GRANT-G3T | |
| Temperature (if stabilised) /°C | | |

## Measured delays /ns

(if needed fill box "Additional Information" below)

| | **Local:** | **Travelling:** |
|---|---|---|
| • Delay from local UTC to receiver 1 PPS-in: | 96.5 | |
| Delay from 1 PPS-in to internal Reference (if different):<br>(see section 2 for details) | -6.4 | |
| • Antenna cable delay: | 142.2 | (1) |
| Splitter delay (if any): | | (1) |
| Additional cable delay (if any): | | (1) |

## Data used for the generation of CGGTTS files

| | |
|---|---|
| • INT DLY (GPS) /ns: | -14.96(C1), -14.96(C2),<br>-14.96(P1), -14.96(P2), -14.96(L5P) |
| • INT DLY (GLONASS) /ns: | -218.32(C1), -218.32(C2)<br>-218.32(P1), -218.32(P2) |
| • CAB DLY /ns: | 142.2 |
| • REF DLY /ns: | 90.1 |
| • Coordinates reference frame: | ITRF |
| Latitude or X /m: | +1243910.11 |
| Longitude or Y /m: | +5462559.47 |
| Height or Z /m: | +3038748.42 |

## General information

| | |
|---|---|
| • Rise time of the local UTC pulse: | <5ns |
| • Is the laboratory air conditioned: | Yes |
| Set temperature value and uncertainty: | $22^0C \pm 1^0C$ |
| Set humidity value and uncertainty: | 50%±5% |

(1) For a trip with closure, not needed if the traveling equipment is used in the same set-up throughout.

# Annex A - Information Sheet

(to be repeated for each calibrated system)

| | |
|---|---|
| Laboratory: | NPLI |
| Date and hour of the beginning of measurements: | **12th March, 2018, 00 hour UTC** |
| Date and hour of the end of measurements: | **10th May, 2018, 24 hour UTC** |

## Information on the system

| | **Local:** | **Travelling:** |
|---|---|---|
| 4-character BIPM code | LIAA | NC4C |
| • Receiver maker and type:<br>Receiver serial number: | Mesit Defence, GTR51<br>1704141 | |
| 1 PPS trigger level /V: | 1V | |
| • Antenna cable maker and type:<br>Phase stabilised cable (Y/N): | Belden | |
| Length outside the building /m: | ~20m | |
| • Antenna maker and type:<br>Antenna serial number: | Novatel, GPS-703-GGG<br>NEG17070062 | |
| Temperature (if stabilised) /°C | | |

## Measured delays /ns

(if needed fill box "Additional Information" below)

| | **Local:** | **Travelling:** |
|---|---|---|
| • Delay from local UTC to receiver 1 PPS-in: | 96.7 | |
| Delay from 1 PPS-in to internal Reference (if different):<br>(see section 2 for details) | | |
| • Antenna cable delay: | 132.9 | (1) |
| Splitter delay (if any): | | (1) |
| Additional cable delay (if any): | | (1) |

## Data used for the generation of CGGTTS files

| | |
|---|---|
| • INT DLY (GPS) /ns: | -23.0(C1), -25.9(P1), -26.9(P2) |
| • INT DLY (GLONASS) /ns: | |
| • CAB DLY /ns: | 132.9 |
| • REF DLY /ns: | 96.7 |
| • Coordinates reference frame: | ITRF |
| Latitude or X /m: | 1243910.24 |
| Longitude or Y /m: | 5462558.20 |
| Height or Z /m: | 3038750.85 |

## General information

| | |
|---|---|
| • Rise time of the local UTC pulse: | <5ns |
| • Is the laboratory air conditioned: | Yes |
| Set temperature value and uncertainty: | $22^0C \pm 1^0C$ |
| Set humidity value and uncertainty: | 50%±5% |

(1) For a trip with closure, not needed if the traveling equipment is used in the same set-up throughout.

# Annex A - Information Sheet

(to be repeated for each calibrated system)

| | |
|---|---|
| Laboratory: | NPLI |
| Date and hour of the beginning of measurements: | **12th March, 2018, 00 hour UTC** |
| Date and hour of the end of measurements: | **10th May, 2018, 24 hour UTC** |

## Information on the system

| | **Local:** | **Travelling:** |
|---|---|---|
| 4-character BIPM code | LIAB | NC4C |
| • Receiver maker and type:<br>Receiver serial number: | Mesit Defence, GTR51<br>1704142 | |
| 1 PPS trigger level /V: | 1V | |
| • Antenna cable maker and type:<br>Phase stabilised cable (Y/N): | Belden | |
| Length outside the building /m: | ~20m | |
| • Antenna maker and type:<br>Antenna serial number: | Novatel, GPS-703-GGG<br>NEG17130019 | |
| Temperature (if stabilised) /°C | | |

## Measured delays /ns

(if needed fill box "Additional Information" below)

| | **Local:** | **Travelling:** |
|---|---|---|
| • Delay from local UTC to receiver 1 PPS-in: | 96.5 | |
| Delay from 1 PPS-in to internal Reference (if different):<br>(see section 2 for details) | | |
| • Antenna cable delay: | 132.2 | (1) |
| Splitter delay (if any): | | (1) |
| Additional cable delay (if any): | | (1) |

## Data used for the generation of CGGTTS files

| | |
|---|---|
| • INT DLY (GPS) /ns: | -21.5(C1), -26.1(P1), -29.5(P2) |
| • INT DLY (GLONASS) /ns: | |
| • CAB DLY /ns: | 132.2 |
| • REF DLY /ns: | 96.5 |
| • Coordinates reference frame: | ITRF |
| Latitude or X /m: | +1243910.03 |
| Longitude or Y /m: | +5462557.56 |
| Height or Z /m: | +3038752.09 |

## General information

| | |
|---|---|
| • Rise time of the local UTC pulse: | <5ns |
| • Is the laboratory air conditioned: | Yes |
| Set temperature value and uncertainty: | $22^0C \pm 1^0C$ |
| Set humidity value and uncertainty: | 50%±5% |

(1) For a trip with closure, not needed if the traveling equipment is used in the same set-up throughout.

# Annex A - Information Sheet

(to be repeated for each calibrated system)

| | |
|---|---|
| Laboratory: | NPLI |
| Date and hour of the beginning of measurements: | **12th March, 2018, 00 hour UTC** |
| Date and hour of the end of measurements: | **10th May, 2018, 24 hour UTC** |

## Information on the system

| | **Local:** | **Travelling:** |
|---|---|---|
| 4-character BIPM code | LIAF | NC4C |
| • Receiver maker and type:<br>Receiver serial number: | Septentrio, POLARX4TR PRO<br>3009587 | |
| 1 PPS trigger level /V: | | |
| • Antenna cable maker and type:<br>Phase stabilised cable (Y/N): | RG213 | |
| Length outside the building /m: | ~20m | |
| • Antenna maker and type:<br>Antenna serial number: | Septentrio, SEPPOLANT_X_MF<br>9940 | |
| Temperature (if stabilised) /°C | | |

## Measured delays /ns

(if needed fill box "Additional Information" below)

| | **Local:** | **Travelling:** |
|---|---|---|
| • Delay from local UTC to receiver 1 PPS-in: | 96.8 | |
| Delay from 1 PPS-in to internal Reference (if different):<br>(see section 2 for details) | 150.3 | |
| • Antenna cable delay: | 168.9 | (1) |
| Splitter delay (if any): | NIL | (1) |
| Additional cable delay (if any): | NIL | (1) |

## Data used for the generation of CGGTTS files

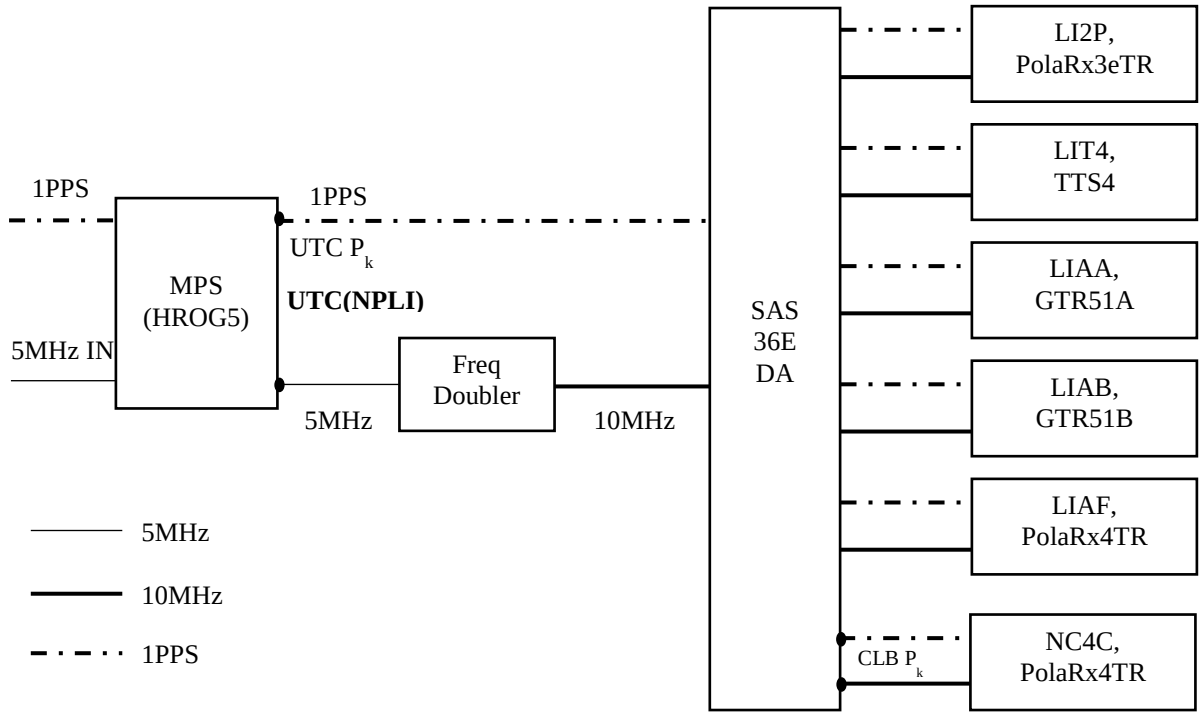
| | |
|---|---|
| • INT DLY (GPS) /ns: | 0.0(P1), 0.0(P2) |
| • INT DLY (GLONASS) /ns: | |
| • CAB DLY /ns: | 168.9 |
| • REF DLY /ns: | 247.1 |
| • Coordinates reference frame: | ITRF |
| Latitude or X /m: | 1243909.953 |
| Longitude or Y /m: | 5462559.754 |
| Height or Z /m: | 3038747.793 |

## General information

| | |
|---|---|
| • Rise time of the local UTC pulse: | <5ns |
| • Is the laboratory air conditioned: | Yes |
| Set temperature value and uncertainty: | $22^0C \pm 1^0C$ |
| Set humidity value and uncertainty: | 50%±5% |

(1) For a trip with closure, not needed if the traveling equipment is used in the same set-up throughout.

# Diagram of the experiment set-up:



# Log of Events / Additional Information :

Two time interval counter (TIC), model SR620, maker Stanford Research Systems are used to measure delays.

TIC serial no 6091 used for local receivers
TIC serial no 5806 used for travelling receiver

For TTS4:
1PPS delay: 96.5ns
1PPS- Frequency offset: 93.6ns
1PPS-Frequency Correction: -6.4ns
Total ref delay: 90.1ns

UTC (NPLI) to 1PPS input of the NC4C (CLB $P_k$): 35.7ns

The delay between the system input point (c201c) and the receiver output 1 PPS (c301c) (TIC reading):165.5ns